AN ASSESSMENT OF THE RATE OF DEFORESTATION IN CENTRAL CROSS RIVER STATE, NIGERIA

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ABSTRACT
This paper appraises the rate of deforestation in Central Cross River State. The data for this study were collected using three (3) multi-date Landsat satellite imageries, Thematic Mapper (TM) of 2003 and Operational Land Imager (OLI) of 2013 and 2023. The study area was extracted from the scene, and a supervised classification method was carried out based on level 1 classification scheme of Anderson et al. (1976), which was used to classify the identified land use and cover categories of the study areas. Five land use and land cover features were used for the study (i.e., built up area, forest, grassland, cropland, and water body). The Anderson et al. (1976) classification scheme was used to analyse the data. The study showed a fluctuating increment of agricultural land, built up areas, and a natural forest cover declining trend, which implies a rapid land use and land cover change across the study area resulting to loss of natural resource and biodiversity. Cultivated land indicates an increasing trend, which implies conversion of other land cover classes to agricultural land, because of rapid population growth, as seen by the expansion of settlement (built up area). The work also showed that though agriculture and development of towns are major cause of deforestation, most of the deforested areas where never put to use. It is therefore recommended therefore that, it is of utmost necessity that people carry out their forest activities with reference to the laws and regulations guiding forest operations so that the future of the forest and its resources is curtained. A ban on timber exploitation in the study area should be enforced, as well as reviewing and strictly enforcing forest laws and regulations, and also encouraging the locals manage their own forest (participatory forest management) to improve compliance. Enlightenment campaign through media such as billboards, radio, television, seminars, workshops, handbill, etc. on the need to desist from deforestation, be organized by the Government, NGOs, and well-meaning individuals.
Key words: Deforestation, Forest, Remote Sense, Timber Logging, Forest Regulations.

INTRODUCTION

One do not need to be a scientist to know that something is disastrously wrong with our planet especially the forests, which are gravely damaged. Forests have been called earth's 'lungs and life-support system', and for good reason. Trees absorb carbon dioxide, which can otherwise harm us. They also emit oxygen, a vital component in the air we breathe. About 80 percent of the world's land-based plants and animals live in forests. Without forests, we could not survive (Awake No. 1 Nov/Dec. 2023). In the tropical regions, forests are taken over by trees in an assorted ecological classification and the headdresses of these trees are intertwined with each other, as a result of the close-knit growth linkage. Within the forests are herbs, shrubs, climbers, and other plant species as well as assorted wildlife. In this vicinity, not less than 60% of all known species of plants are found in the tropical rainforests of the world (Yusuf and Razaq, 2024).

Each year, billions of trees are cut down, mostly to clear land for agricultural use. Illegal logging, a multi-billion-dollar business, and commercial exploitation continues to drive tropical deforestation at a remorseless rate. Since the late 1940's, half the world's rain forests have disappeared. When a forest is destroyed, the benefits of the ecosystem and all that it provides go with it (Awake No. 1 Nov/Dec. 2023). According to the Food and Agriculture Organization's (FAO) Global Forest Resources Assessment, deforestation is the conversion of forest to other land use independently of whether human-induced or not. That is, deforestation is essentially referring to a change in land use, not in tree cover (FAO, 2022; Yusuf and Razaq, 2024).

Trees in forested and agricultural landscapes are particularly important because they disproportionately provide high values of environmental services and biodiversity. Mankind's activities on the environment in his quest for development have resulted in a continuous and serious degradation of the ecosystem, thus pose a threat to both his present and future living. Rapid population growth and urbanization is of great concern to the sustainability of cities, the more people are there on the earth, the greater the impact on the environment and pressures on resources. As such, the unwise use of the natural environment due to

ignorance, poverty, overpopulation and greed amongst others has led to the deforestation and degradation of the environment (Ogunwale, 2015).

Currently, deforestation constitutes one of the global development challenges. Specifically, it is the most serious long term environmental problem facing the world and Nigeria is not an exception (Ogunwale, 2015). This paper is aimed at determining the rate of deforestation in Central Cross River State, Nigeria.

MATERIALS AND METHODS

Land Use/Land Cover changes of the study area

The data for this study were collected through the use of three (3) multi-date Landsat satellite imageries, Thematic Mapper (TM) of 2003 and Operational Land Imager (OLI) of 2013 and 2023. The study area was extracted from the scene, and a supervised classification method was carried out based on level 1 classification scheme of Anderson *et al.* (1976), which was used to classify the identified land use and cover categories of the study areas. Five land use and land cover features were used for the study (i.e., built up area, forest, grassland, cropland, and water body).

Four basic pre-processing operations were done namely: image reconstruction, to extract area of interest from the general satellite scene; image enhancement, to improve visual interpretation by increasing apparent contrast among various features in the image; radiometric correction, to correct the sun elevation was perform on the raw data; a band combination of 2,3,4 was used for 2003 images while 3,4,5 combination was used for the 2013 and 2023 landsat 8 (OLI) because it produce superior results due to the sensitivity of band 4 and 3 to vegetation cover and sensitivity of band 4 to water contents (Robert, Frohn and Autrey, 2009).

Table 1: Classification Scheme used for this Study

S/N	Class	Description
1	Water bodies	Open water features such as rivers, streams, lakes and reservoirs.
2	Built-up	Areas under urban and rural built-up including homestead area such residential, commercial villages, settlements, road network.
3	Cropland	Areas suitable for cultivating crops.
4	Forest cover	Vegetated lands, shrubs and trees.

| 5 | Grassland | Trees, natural vegetation, gardens, parks and playgrounds, grassland, agricultural lands, and crop fields. |

Source: Field Survey, 2023.

Table 2: Characteristics of Landsat Images used for the Study

Date of Acquisition	Sensor	Path	Row	Multispectral Band	Thermal Band	Spectral Range (micrometers)	Spatial Resolution (pixel spacing)	Source
1993	TM	190	56	1to5 and 7	6	10.45-12.45	30	
2013	ETM+	190	56	1to5 and 7	10 and 11	10.45-12.45	30	USGS
2023	OLI and TIRS	189	56	1to7 and 9	10 and 11	10.60-12.51	30	

USGS (United State Geological Survey) website

Analysis of the Rate of Land Use and Land Cover Change in the Study Area

The extent of land use change was analyzed by subtracting the reference year (2023) from the base year. It is represented mathematically as:

$E_T = B - A$

A= the base year (1993)

B=the reference year (2023)

E_T =total extent of forest land

Change Analysis by Area Calculation

There are three steps in calculating change detection by area calculation:

a) The first step is the calculation of the magnitude of change, which is derived by subtracting observed change of each period of years from the previous period of years.

b) The second step was the calculation of the trends, that is, the percentage change of each of the land-use, by subtracting the percentage of the previous land-use from the recent land-use divided by the previous land-use and multiplied by 100 (B-A/Ax100).

c) The last, is the calculation of the annual rate of change by dividing the percentage change by 100

and multiplied by the number of the study years, that is, 30 years (1993-2023).

RESULTS AND DISCUSSION

Analysis of the Land Use/Land Cover of the Study Areas for Boki (1993, 2013 & 2023)
Land Use and Land Cover of 1993

The Anderson *et al.* (1976) classification scheme was used. Figure 1 shows result of the analysis of 1993 supervised maximum likelihood classification of the study area. The map revealed five (5) categories of land use and land cover table depicting forest, grassland, settlements, croplands and water bodies.

The areal extent of these land use and land cover classes revealed that, the dominant land cover in the study area is forest cover with an area coverage that amounted to 1698.94 km^2 (58.46%) of the total area, located in almost all parts of the study area. The next largest is grasslands also covers a significant area of 593.72 km^2 (20.43%). Additionally, built up areas however, cover an area of 109.15 km^2 (3.76%) while croplands and water bodies occupy an area of 490.03 km^2 (16.86%) and 14.29 km^2 (0.49%) respectively as indicated on figure 1.
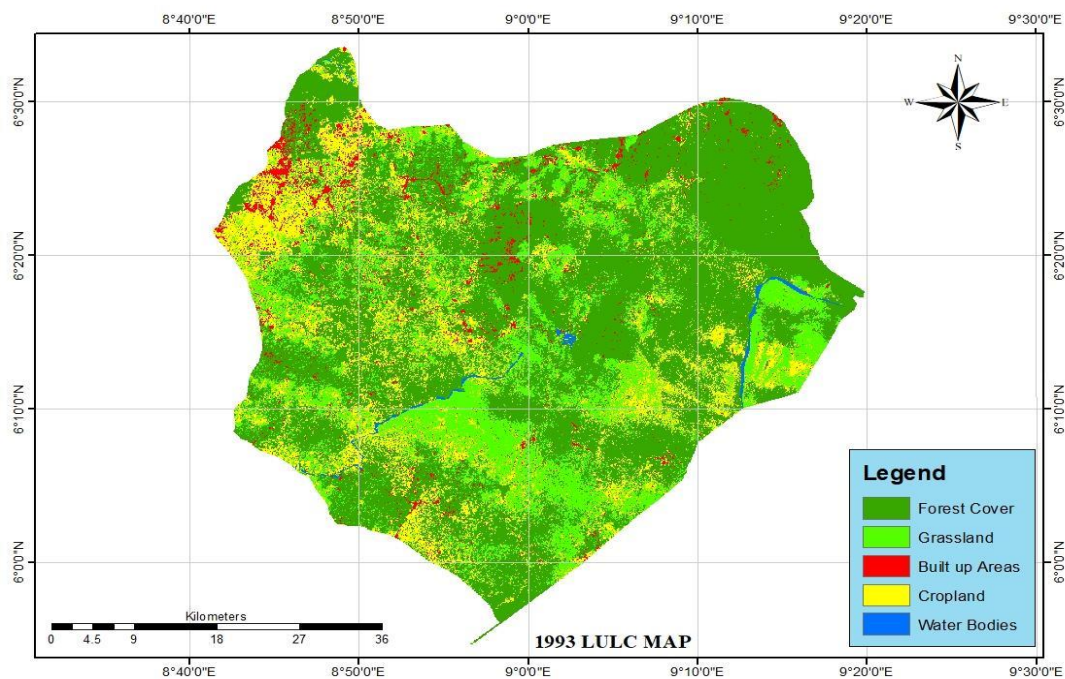
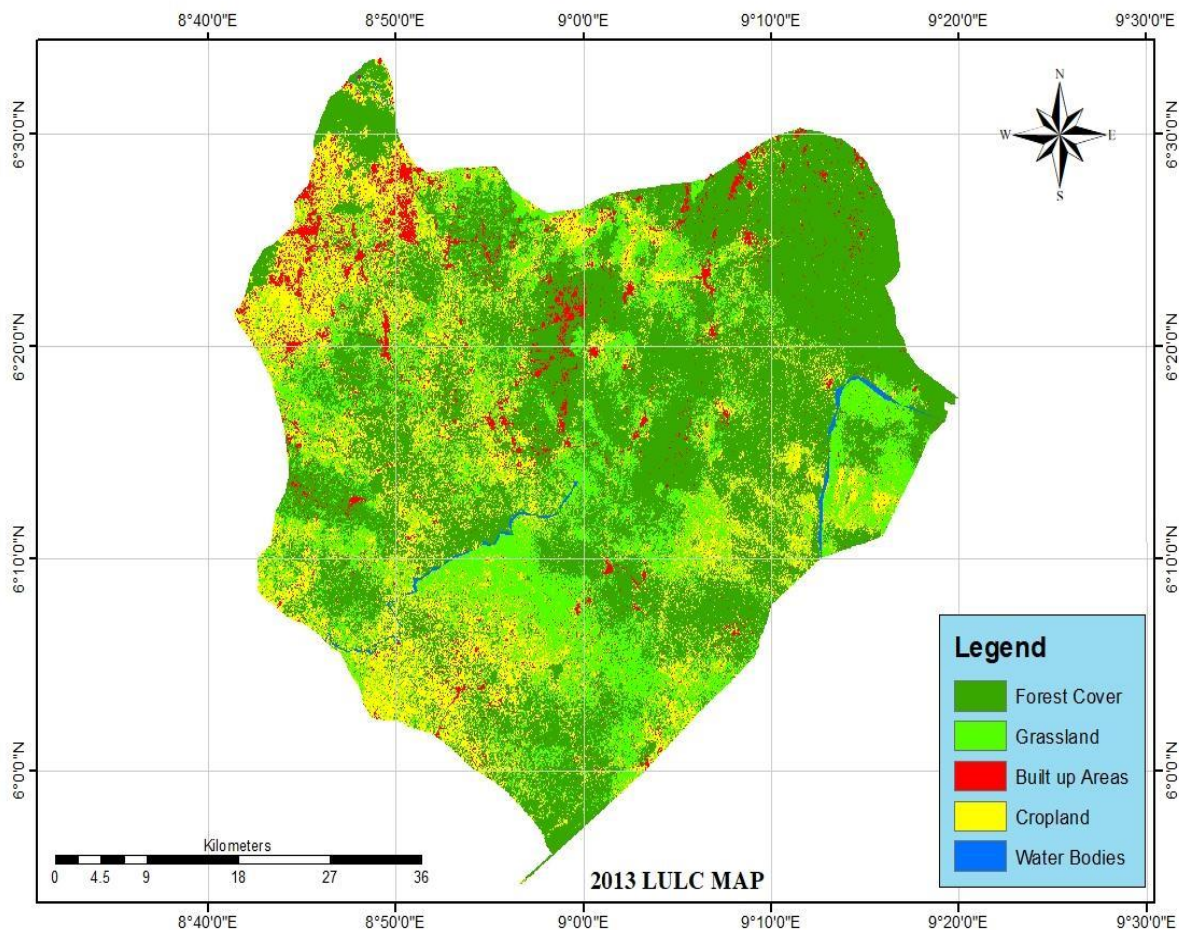**Figure 1: 1993 LULC Distribution Map of Boki Generated from LandSat 7 TM**

Source: Field Survey, 2023.

LULC = Land Use and Land Cover

Land Use and Land Cover of 2013

The areal extent of these land use and land cover classes revealed that, the dominant land cover in the study area was forest cover with an area coverage of 1509.82 km^2 (51.95%) of the total area, located in the northeastern section of the study area although witnessed a decrease of 6.51%. Forest cover decreased significantly to 1509.82 km^2 (51.95%) in 2013 from 1698.94 km^2 (58.46%) in 1993. Also, settlements areas witnessed an increase of 152.55 km^2 (5.25%) in 2013 from 109.15 km^2 (3.76%) in 1993. The increase in built up areas can be attributed to the increase in population while croplands and water bodies occupies an area of 629.94 km^2 (21.67%) and 12.51 km^2 (0.43%) respectively as reveal in figure 2.

Figure 2: 2013 LULC Distribution Map of Boki Generated from LandSat 8 OLI
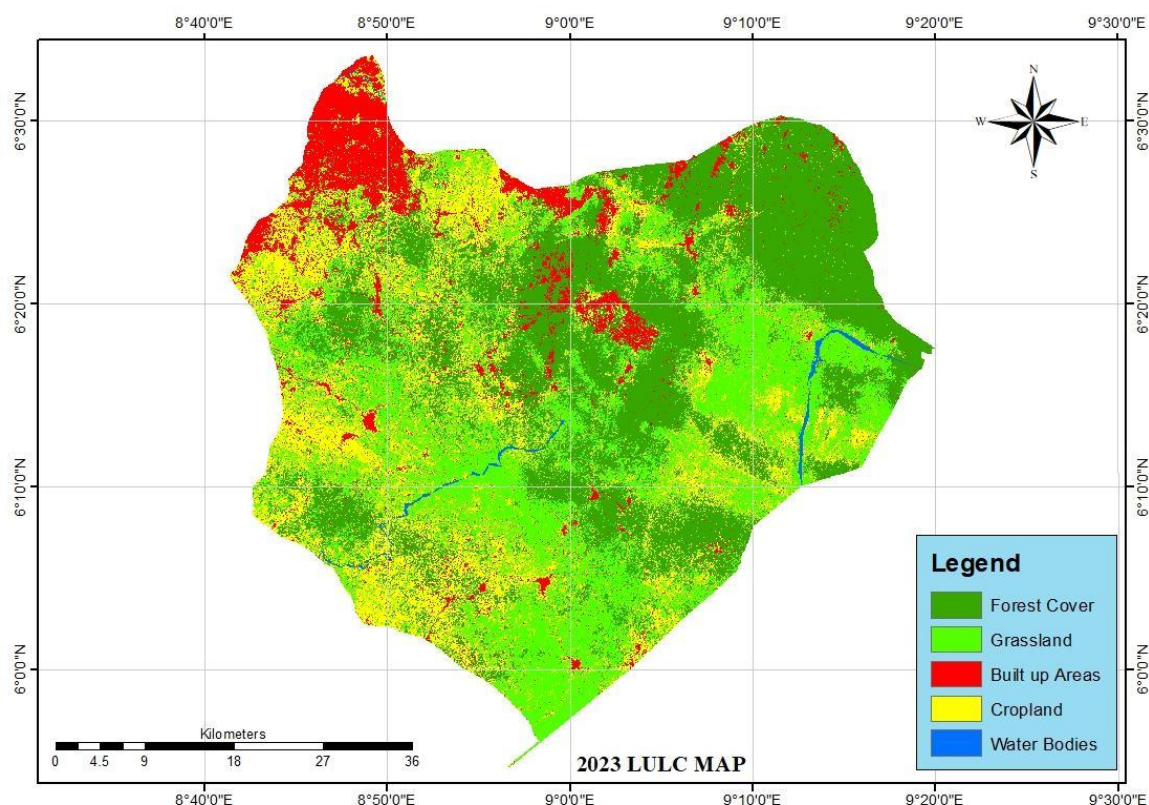
Source: Field Survey, 2023.
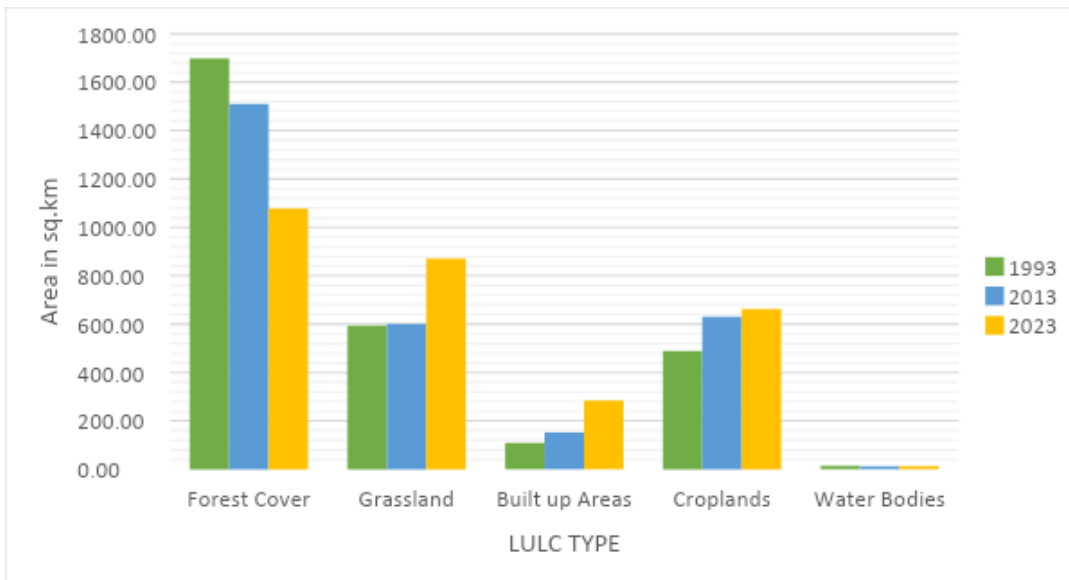
Land Use and Land Cover of 2023

Figure 3, indicates the land use and land cover (LULC) map of Boki for the year 2023 and revealed that the dominant land cover in the study area was forest cover with an area coverage of 1077.40 km^2 (37.07%) of the total area, located in the northern and central section of the study area although witnessed an increase of 14.88%. This is followed by grassland with areal coverage of 870.18 km^2 (29.94%). Croplands areas also witnessed significant increase area of 661.51 km² (22.76%). Furthermore, built up areas continues to witness increase from 152.55 km^2 (5.25%) in 1993 to 284.34km^2 (9.78%) in 2023. The increase in built up areas can be attributed to continuous influx of people to the area while water bodies occupies an area of 12.92 km^2 (0.44%)

Figure 3: 2023 LULC Distribution Map of Boki Generated from LandSat 8 OLI

Source: Field Survey, 2023.

Figure 4: Land Use and Land Cover Trend Chart for Boki
Source: Field Survey, 2023.

Similarly, figure 4 and table 3 shows the trend and area coverage of each land use and land cover types for the years under consideration.

Table 3: Land Use and Land Cover Distribution for Boki (1993, 2013 and 2023)

LULC	1993		2013		2023	
Land Cover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Forest Cover	1698.94	58.46	1509.82	51.95	1077.40	37.07
Grassland	593.72	20.43	601.52	20.70	870.17	29.94
Built up Areas	109.15	3.76	152.55	5.25	284.34	9.78
Croplands	490.03	16.86	629.94	21.67	661.51	22.76
Water Bodies	14.29	0.49	12.51	0.43	12.92	0.44
Total	**2906.34**	**100.00**	**2906.34**	**100.00**	**2906.34**	**100.00**

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover between 1993 and 2013

The magnitude of change of vegetation area for 20 years between 1993 and 2013 shows that forest decreased by -189.13 km^2 representing a change (-11.13%) of the total change for the period as shown in Table 4. Built up areas have one of the highest annual rates of change of 1.99% while water bodies have the least annual rate of change of -0.62%. The period also witnessed a decrease in water.

Table 4: Magnitude and Percentage of Change in Land Use/Land Cover of Boki between 1993 and 2013

LULC Class	1993 Extent (km^2)	2013 Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of Change %
Forest Cover	1698.94	1509.82	-189.13	-11.13	-0.56
Grassland	593.72	601.52	7.80	1.31	0.07
Built up Areas	109.15	152.55	43.40	39.77	1.99
Croplands	490.03	629.94	139.91	28.55	1.43
Water Bodies	14.29	12.51	-1.78	-12.43	-0.62

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover between 2013 and 2023

The magnitude of change of vegetation area for 10 years between 2013 and 2023 indicates that forest cover decreased further by -432.42 km^2 representing a change (-28.64%) of the total change with annual rate of change of -2.86% for the period as shown in Table 5. Built up areas have annual rates of change of 8.64%. The period also witnessed an increase in croplands. The croplands increased by 31.57 km^2 representing 5.01% of the total change with annual rate of 0.50%.

Table 5: Magnitude and Percentage of Change in Land Use/Land Cover of Boki between 2013 and 2023

LULC Class	2013 Extent (km²)	2023 Extent	Magnitude of Change (km²)	Percentage of Change	Annual Rate of Change %
Forest cover	1509.82	1077.40	-432.42	-28.64	-2.86
Grassland	601.52	870.18	268.66	44.66	4.47
Built up Areas	152.55	284.34	131.79	86.39	8.64
Cropland	629.94	661.51	31.57	5.01	0.50
Water Bodies	12.51	12.92	0.40	3.23	0.32

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover between 1993 and 2023

The magnitude of change of the various land use and cover categories for 30 years between 1993 and 2023. Findings shows that settlements areas continue to witness an increase, with an annual rate of change of 5.35% while croplands have annual rate of change of 1.17% representing 34.99% of the total change within the study period.

Table 6: Magnitude and Percentage of Change in LULC between 1993 and 2023

LULC Class	1993 Extent (km^2)	2023 Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of Change %
Forest cover	1698.94	1077.40	-621.54	-36.58	-1.22
Grassland	593.72	870.18	276.46	46.56	1.55
Built up Areas	109.15	284.34	175.19	160.51	5.35
Croplands	490.03	661.51	171.48	34.99	1.17
Water Bodies	14.29	12.92	-1.37	-9.61	-0.32

Source: Field Survey, 2023.

Analysis of Land Use and Land Cover of Obubra for 1993

Figure 5 reveals the classified map of 1993 land use and land cover map of Obubra local government areas, the map indicates that the dominant land cover in the study area is forest cover with areal coverage of 584.55 km^2 (50.58%). Grassland on the other hand, occupies an area of 332.69 km^2 (28.79%). Croplands covers an area of 142.22 km^2 (12.31%). Additionally, settlements areas however, cover an area of 68.87 km^2 (5.96%) while water bodies occupy an area of 27.42 km^2 (2.37%) as indicated on figure 5. This is in line with the work of Olorunfemi *et al.* (2019) who carried out similar work.
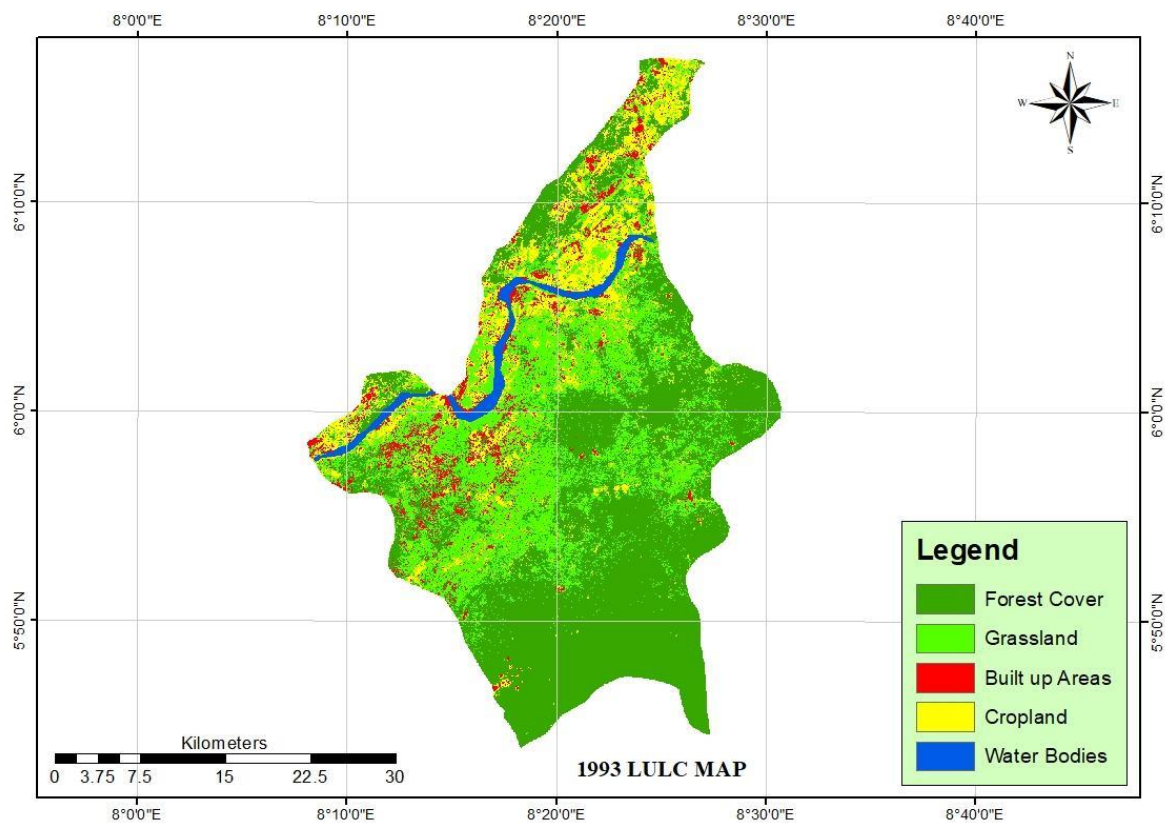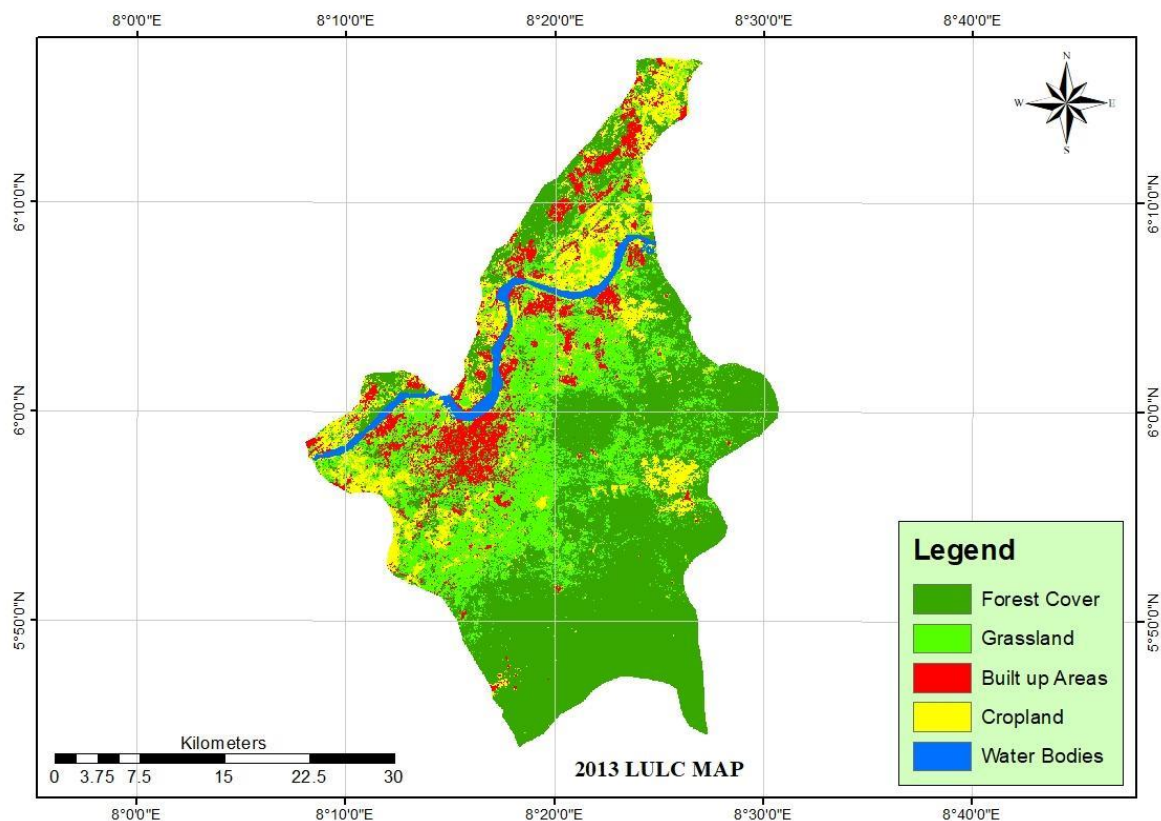
Figure 5: 1993 LULC Distribution Map of Obubra Generated from LandSat 7 ETM+
Source: Field Survey, 2023.

Analysis of Land Use and Land Cover of Obubra for 2013

Figure 6 reveals the classified map of 2013 land use and land cover map of Obubra, this period also indicates that the dominant land cover in the study area is forest cover with areal coverage of 569.66 km^2 (49.29%) in 1993 but decreases slightly to 370.78 km^2 (23.33%).

Grassland cover on the other hand, which occupies an area of 295.46 km^2 (25.57%) in 1993 decreased further to 243.45 km^2 (15.32%). Croplands covers an area of 142.22km^2 (12.31%) in 1993 but increased slightly to 148.14 km^2 (12.82%). Additionally, settlements areas however, cover an area of 68.87 km^2 (5.96%) in 1993 increase 112.94 km^2 (9.77%) while water bodies remain relatively stable at 29.45 km^2 (2.55%). This is in line with the work of Olorunfemi *et al.* (2019) who carried out similar work.

Figure 6: 2013 LULC Distribution Map of Obubra Generated from LandSat8 OLI
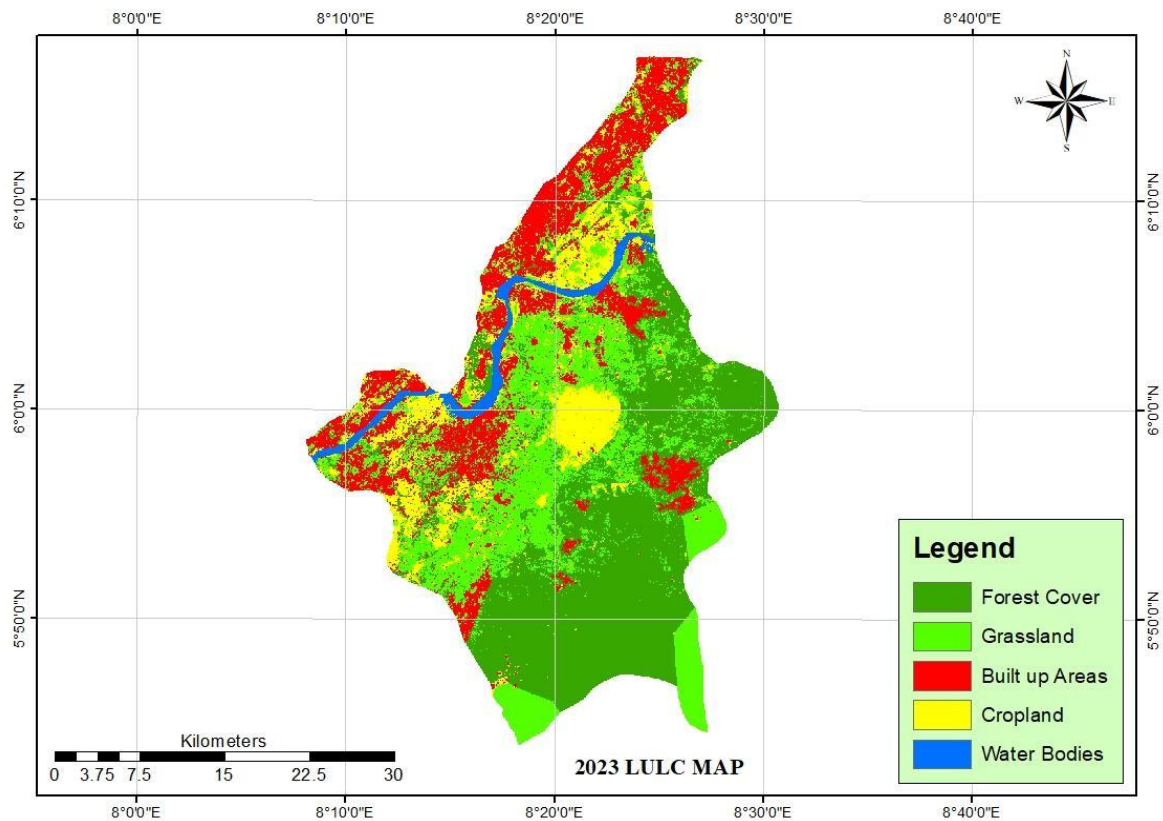
Source: Field Survey, 2023.

Analysis of Land Use and Land Cover of Obubra for 2023

Figure 7 reveals the classified map of 2023 land use and land cover map of Obubra. This period also indicates that cropland with area coverage of 146.14km^2 (12.65%) in 2023 from 148.14 km2 (12.82%) in 2013. There was a slight increase of about (0.17%).

Forest cover on the other hand, which occupies an area of 432.62 km^2 (37.44%) in 2023 witness a further decreased from 569.66 km^2 (49.29%) in 2013. Grassland covers an area of 319.92 km^2 (27.69%) in 2023 from 295.26 km2 (25.57%) in 2013. Additionally, built up areas however, continues to increase from 112.94 km^2 (9.77%) in 2013 increase 228.87 km^2 (19.63%) while water bodies remain relatively stable at 30.00 km^2 (2.60%).
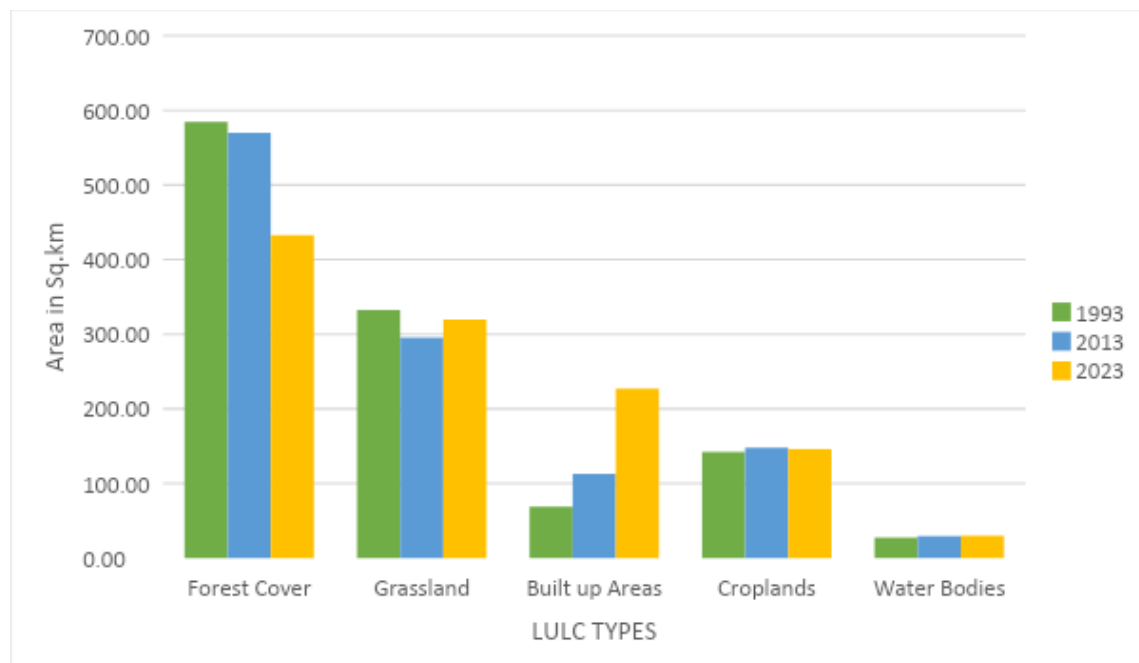
Figure 7: 2023 LULC Distribution Map of Obubra Generated from Landsat OLI

Source: Field Survey, 2023.

Figure 8 and table 7 shows the trend and statistics of the various land use and land cover on the study area.

Figure 8: Trend Chart of the various Land Use and Land Cover Map of Obubra

Source: Field Survey, 2023.

Table 7: Land Use and Land Cover Distribution for Obubra (1993, 2013 and 2023)

LULC	1993		2013		2023	
LandCover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Forest Cover	584.55	50.58	569.66	49.29	432.62	37.44
Grassland	332.69	28.79	295.46	25.57	319.92	27.69
Built up Areas	68.87	5.96	112.94	9.77	226.87	19.63
Croplands	142.22	12.31	148.14	12.82	146.14	12.65
Water Bodies	27.42	2.37	29.45	2.55	30.00	2.60

Total	**1155.64**	**100**	**1155.64**	**100**	**1155.55**	**100**

Magnitude and Percentage of Change in Land Use/Landover between 1993 and 2013

The magnitude of change of vegetation area for 20 years between 1993 and 2013 shows that forest decreased by -14.90 km^2 representing a change (-2.55%) of the total change for the period as shown in Table 8. Settlements have one of the highest annual rates of change of 3.20% while croplands have annual rate of change of 0.21%.

Table 8: Magnitude and Percentage of Change in Land Use/Land Cover for Obubra between 1993 and 2013

LULC Class	1993 Extent (km^2)	2013 Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of Change %
Forest Cover	584.55	569.66	-14.90	-2.55	-0.13
Grassland	332.69	295.46	-37.23	-11.19	-0.56
Built up Areas	68.87	112.94	44.07	64.00	3.20
Croplands	142.22	148.14	5.92	4.16	0.21
Water Bodies	27.42	29.45	2.03	7.40	0.37

Magnitude and Percentage of Change in Land Use/Land Cover between 2013 and 2023

The magnitude of change of vegetation area for 10 years between 2013 and 2023 indicates that forest cover decreased further by -137.03 km^2 representing a change (-24.06%) of the total change with annual rate of change of -2.41% for the period as shown in Table 9. built up areas have the highest annual rates of change of 10.09%. The period also witnessed a decrease in croplands. The croplands increased by -2.00 km^2 representing -1.35% of the total change with annual rate of -0.14% as reveal in table 9.

Table 9: Magnitude and Percentage of Change in Land Use/Land Cover for Obubra between 2013 and 2023

LULC Class	2013 Extent (km^2)	2023 Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of Change %
Forest cover	569.66	432.62	-137.03	-24.06	-2.41
Grassland	295.46	319.92	24.46	8.28	0.83
Built up Areas	112.94	226.87	113.93	100.88	10.09
Croplands	148.14	146.14	-2.00	-1.35	-0.14
Water Bodies	29.45	30.00	0.55	1.87	0.19

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover for Obubra between 1993 and 2023

The magnitude of change of the various land use and cover categories for 20 years between 1993 and 2023. Findings shows that built up areas continue to witness an upsurge, with annual rates

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of change of 7.65% while water bodies has an annual rate of change of 0.31% for the period as shown on Table 10. The period also witnessed a slight increase in croplands

Table 10: Magnitude and Percentage of Change in LULC for Obubra between 1993 and 2023

LULC Class	1993 Extent (km^2)	2023 Extent (km^2)	Magnitude of Change (km^2)	Percentage of Change	Annual Rate of Change %
Forest cover	**584.55**	**432.62**	**-151.93**	**-25.99**	**-0.87**
Grassland	332.69	319.92	-12.76	-3.84	-0.13
Built up Areas	68.87	226.87	158.00	229.43	7.65
Croplands	142.22	146.14	3.92	2.75	0.09
Water Bodies	27.42	30.00	2.58	9.41	0.31

Source: Field Survey, 2023.

Analysis of Land Use and Land Cover of Ikom for 1993

Figure 11 reveals the classified map of 1993 land use and land cover map of Ikom Local Government areas. The map indicates that the dominant land cover in the study area is grassland with an area coverage of 881.52 km^2 (44.15%) of the total area, located at the various section of the map but more pronounced at the northern and southern sections of the study area. Forest cover on the other hand, occupies an area of 754.33km^2 (37.78%). Croplands covers an area of 195.75 km^2 (9.80%). Also, settlements areas cover an area of 137.51 km^2 (6.65%) while water bodies occupy an area of 32.68 km^2 (1.64%).
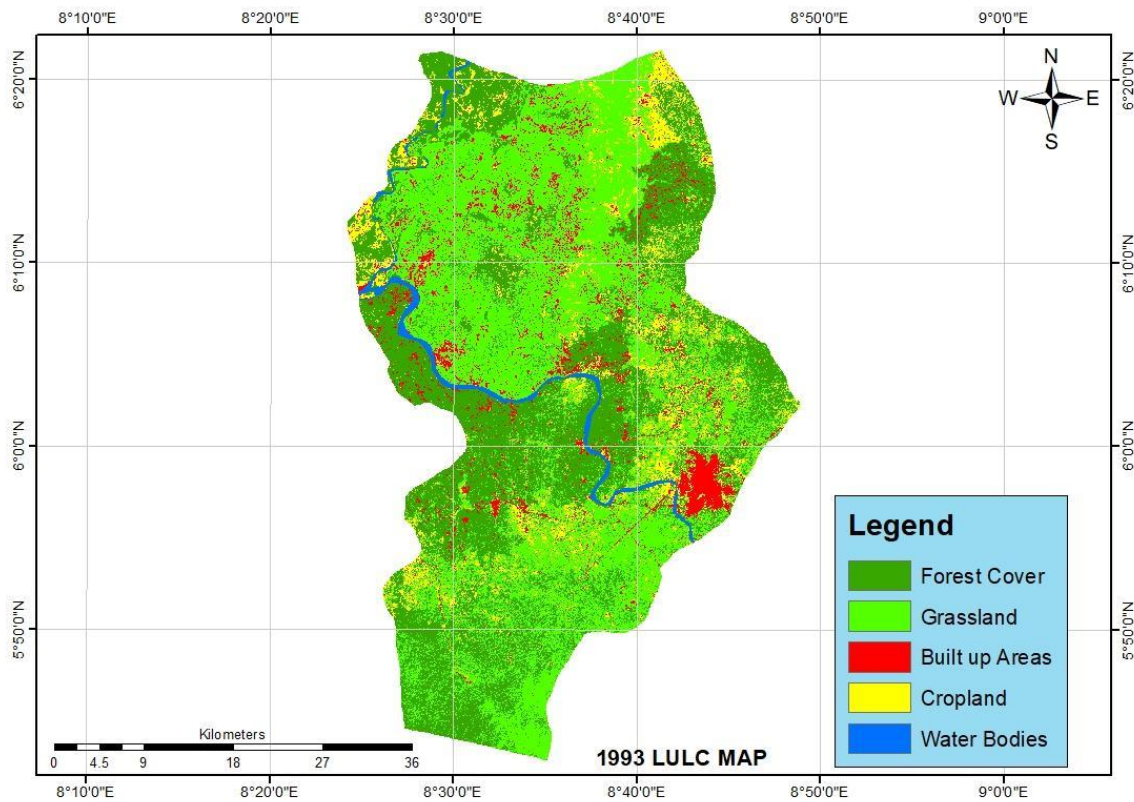
Figure 9: 1993 Land Use/Land Cover Distribution Map of Ikom Generated from LandSat 7 ETM
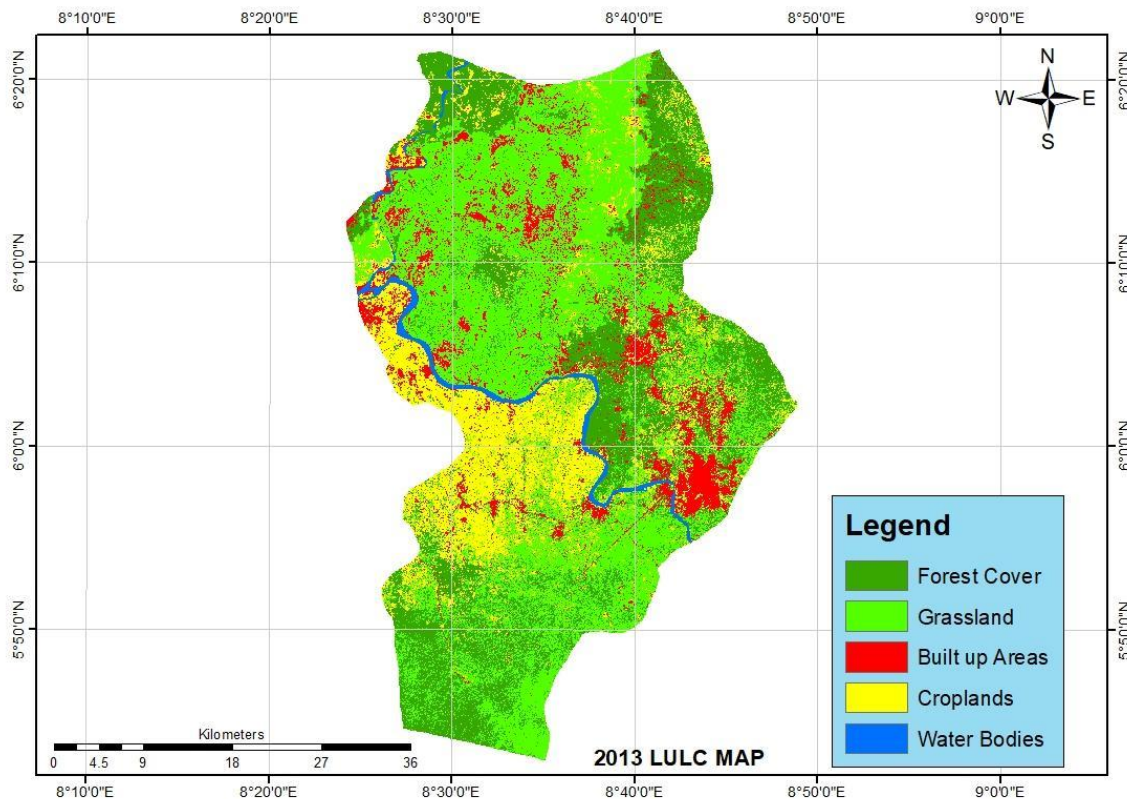
Source: Field Survey, 2023.

Analysis of Land Use and Land Cover of Ikom for 2013

Figure 9 reveals the classified map of 2013 land use and land cover map of Ikom, this period also indicates that the dominant land cover in the study area was grasslands which covers an area of 881.52 km^2 (44.15%) in 1993 but decreased to 859.99km^2 (43.07%) in 2013. Cropland with an area coverage of 195.75 km^2 (9.80%) in 1993 but increased to 344.17 km^2 (17.24%) in 2013 of the total area, located at the northern and southern sections of the of the study area.

Forest cover on the other hand, which occupies an area of 754.33km^2 (37.78%) in 1993 increased further to 557.38 km^2 (27.91%). Additionally, built up areas however, cover an area of 137.51 km^2 (6.65%) in 1993 increase to 201.21km^2 (10.08%) while water bodies remain relatively stable at 34.03 km^2 (1.70%).
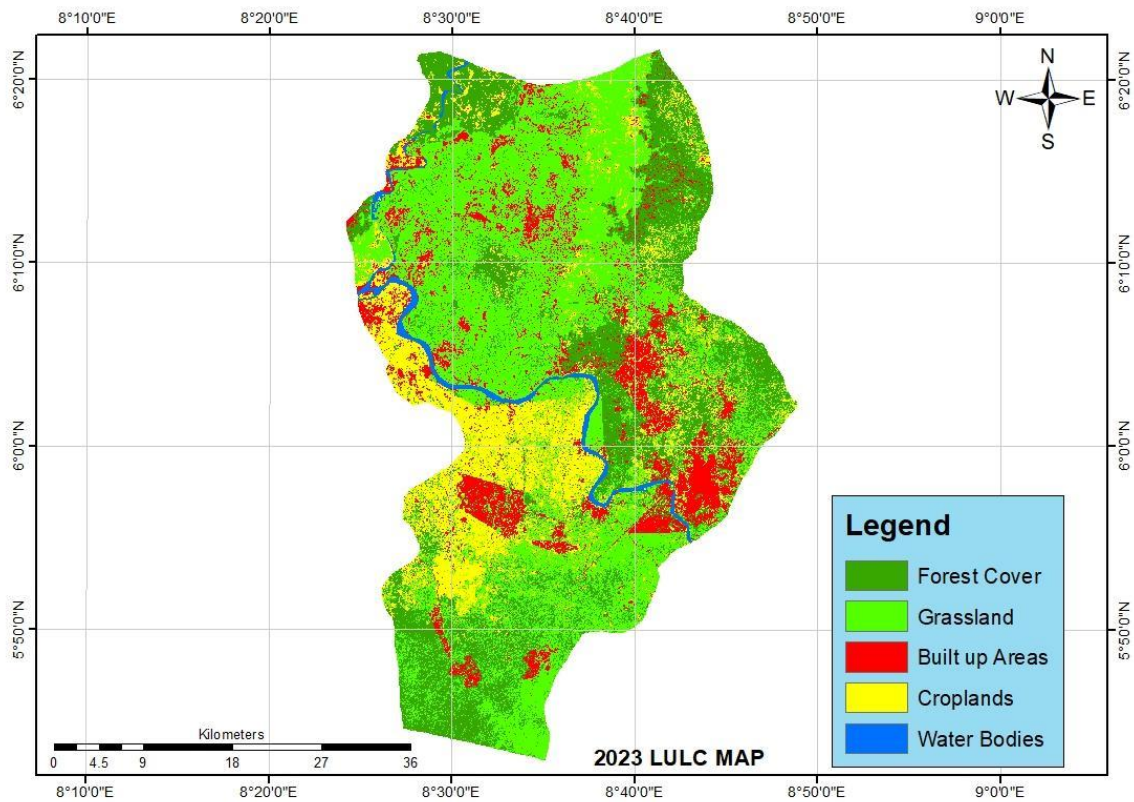
Figure 10: 2013 Land Use/Land Cover Distribution Map of Ikom Generated from LandSat 8 OLI
Source: Field Survey, 2023.

Analysis of Land Use and Land Cover of Ikom for 2023

Figure 10 reveals the classified map of 2023 land use and land cover map of Ikom, this period also indicates that the dominant land cover in the study area was grassland which covers an area of 859.99km^2 (43.07%) in 2013 but decreased to 852.88 km^2 (42.71%) in 2023. Cropland with an area coverage of 344.17 km^2 (17.24%) in 2013 but decreases slightly to 329.26 km^2 (16.49%) in 2023 of the total area. Forest cover on the other hand which occupies an area of 557.38 km^2 (27.91%) in 2013 decreased further to 530.69 km^2 (26.58%) in 2023. Additionally, built up areas however, cover an area of 201.21km^2 (10.08%) in 2013 increase to 248.88 km^2 (12.46%) in 2023 while water bodies increased to 34.98 km^2 (1.75%).

Figure 11: 2023 Land Use/Land Cover Distribution Map of Ikom Generated from LandSat 8 OLI

Source: Field Survey, 2023.

Figure 12 and table 12 shows the trend and statistics of the various land use and land cover on the study area.
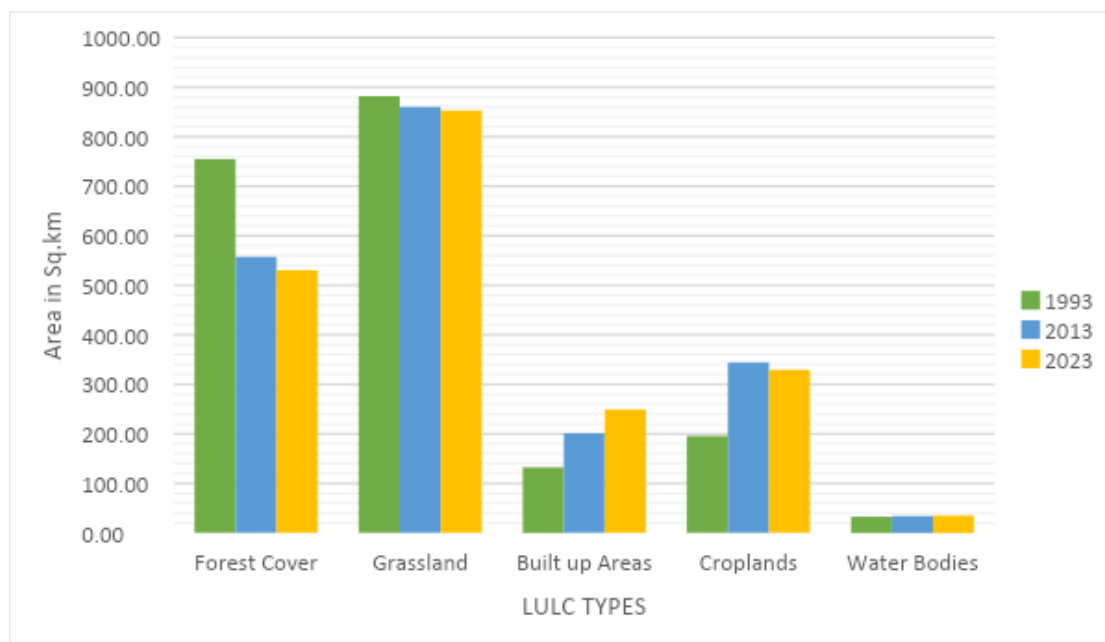
Figure 12: Land Use/Land Cover Trend Chart of Land Use and Land Cover for Ikom

Source: Field Survey, 2023.

Table 11: Land Use and Land Cover Distribution for Ikom (1993, 2013 and 2023)

LULC	1993		2013		2023	
Land Cover Category	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)	Area (Sqkm)	Area covered (%)
Forest Cover	754.33	37.78	557.38	27.91	530.69	26.58
Grassland	881.52	44.15	859.99	43.07	852.88	42.71
Built up Areas	132.51	6.64	201.21	10.08	248.88	12.46
Croplands	195.75	9.80	344.17	17.24	329.26	16.49
Water Bodies	32.68	1.64	34.03	1.70	34.98	1.75
Total	1996.79	100	1996.79	100	1996.79	100

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover between 1993 and 2013

The magnitude of change of agroforest area for 20 years between 1993 and 2013 shows that forest decreased by -196.95 km^2 representing a change (-26.11%) of the total change for the period with an annual rate of change of -1.31% as shown in Table

.

12. Croplands have one of the highest annual rates of change of 3.79%. The period also witnessed a decrease in grasslands. The grasslands decreased by -21.53 km^2 (-2.44%) of the total change whereas built up areas increased by 2.59% annually

Table 12: Magnitude and Percentage of Change in Land Use/Land Cover for Ikom between 1993 and 2013

LULC Class	1993 Extent km²	2013 Extent km²	Magnitude of Change km²	Percentage of Change	Annual Rate of Change %
Forest Cover	754.33	557.38	-196.95	-26.11	-1.31
Grassland	881.52	859.99	-21.53	-2.44	-0.12
Built up Areas	132.51	201.21	68.70	51.85	2.59
Croplands	195.75	344.17	148.42	75.82	3.79
Water Bodies	32.68	34.03	1.35	4.14	0.21

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover between 2013 and 2023

The magnitude of change of agroforest area for 10 years between 2013 and 2023 indicates that forest cover decreased further by -26.70 km² (-4.79%) of the total change with annual rate of change of -0.48% for the period as shown in Table 13. Built up areas have the highest annual rates of change of 2.37%. The period also witnessed a decrease in croplands. The croplands decreased by -14.92 km² representing -4.33% of the total change with annual rate of -0.43% as reveal in table 13, while water bodies have an annual rate of change of 0.28%.

Table 13: Magnitude and Percentage of Change in Land Use/Land Cover for Ikom between 2013 and 2023

LULC Class	2013 Extent (km²)	2023 Extent (km²)	Magnitude of Change (km²)	Percentage of Change	Annual Rate of Change %

Forest cover	557.38	530.69	-26.70	-4.79	-0.48
Grassland	859.99	852.88	-7.11	-0.83	-0.08
Built up Areas	201.21	248.88	47.67	23.69	2.37
Croplands	344.17	329.26	-14.92	-4.33	-0.43
Water Bodies	34.03	34.98	0.95	2.78	0.28

Source: Field Survey, 2023.

Magnitude and Percentage of Change in Land Use/Land Cover between 1993 and 2023

Table 14 indicates the magnitude of change of the various land use and cover categories for 30 years' period between 1993 and 2023. Findings shows that built up areas continue to witness an increase with the highest annual rates of change of 2.93%. This is followed by croplands which has annual rate of change of 2.27% for the period as shown in Table 14. The period also witnessed a decrease in forest lands. The forest decreased by -223.64 km^2 representing a change (-29.65%) of the total change with annual rate of change of -0.99% for the period under study. This is an indication of increased lumbering activities and high rate of deforestation across the study area.

Table 14: Magnitude and Percentage of Change in Land Use/Land Cover for Ikom between 1993 and 2023

LULC Class	1993 Extent km^2	2023 Extent km^2	Magnitude of Change km^2	Percentage of Change	Annual Rate of Change %
Forest cover	754.33	530.69	-223.64	-29.65	-0.99

Grassland	881.52	852.88	-28.64	-3.25	-0.11
Built up Areas	132.51	248.88	116.37	87.83	2.93
Croplands	195.75	329.26	133.50	68.20	2.27
Water Bodies	32.68	34.98	2.30	7.04	0.23

Source: Field Survey, 2023.

Discussion

The research findings indicated a fluctuating increment of agricultural land, built up areas, while the natural forest cover shows a declining trend. This implies that there was a rapid land use and land cover change across the study areas. This resulted in loss of natural resource and biodiversity. Agriculture land indicates an increasing trend, which depicts conversion of other land cover classes to cultivated land because of rapid population growth in the study area. In addition to this, there was an expansion of settlement (village) in 2013 due to population growth. The findings of this study is consistent with other studies carried out by Negassa *et al.,* (2020) in Komto Protected Forest priority area, East Wollega Zone Ethiopia.

The work also showed that though agriculture and development of towns are major cause of deforestation, most of the deforested areas where never put to use.

CONCLUSION AND RECOMENDATIONS

Forestry violations are becoming increasingly high by the day. One of the most common forestry violations is illegal felling of trees, which is understood as felling of forest stands made in violation of legal requirements, without registration of documents, or in excess of the permitted amount, or outside the cutting area. This trend is gradually becoming the new normal due low compliance with forest regulations despite government efforts. There have been several faint measures to curb this menace.

The study showed a fluctuating increment of agricultural land, built up areas, and a natural forest cover declining trend, which implies a rapid land use and land cover change across the study area resulting to loss of natural resource and biodiversity. Cultivated land indicates an increasing trend, which implies conversion of other land cover classes to agricultural land, because of rapid population growth, as seen by the

expansion of settlement (built up area). The work also showed that though agriculture and development of towns are major cause of deforestation, most of the deforested areas where never put to use.

As the population increases, the need for increase in agricultural land cannot be over emphasized as evident in the change in land use and land cover change as most of the people in the study area are rural dwellers whose major stay is farming, their activities ranges from total clear felling of the forest to partial deforestation, timber business to non-timber forest products (NTFPs) extraction, all of this being drivers of land use and land change since rural dwellers depend solely on the forest for all their daily needs.

It is therefore of utmost necessity that the people carry out their forest activities with reference to the laws and regulations guiding forest operations so that the future of the forest and its resources is curtained. And if the government is committed to sustainable forest management, its forest policies, laws and regulations will be guided by the national goals and principles of the Constitution.

Recommendations

The following recommendations were made based on the findings of this study:

I. Proper and integrated approach in implementing policies and strategies related to land use and land cover management is required in the various study locations.

II. Forest laws and regulations should be reviewed and strictly enforced to abate deforestation.

III. The local people should be encouraged to manage their own forest (participatory forest management) to improve compliance.

IV. Alternative means of livelihood such as provision of employment by the government, NGOs and private sector to members of communities in the study area.

V. Enlightenment campaigned through media such as billboards, radio, television, seminars, workshops, handbill, etc. on the effects of illegal timber logging be organized by the Government, NGOs, and well-meaning individuals.

VI. Ban on timber exploitation in the state should be enforced since compliance with forest regulations was higher during the period where the ban was on, so as to ensure adequate control and implementation.

REFERENCES

Anderson, J. R. (1976). A Land Use and Land Cover Classification System for Use with Remote

Sensor Data (Vol. 964). US Government Printing Office.

Awake No. 1 (Nov/Dec. 2023). Watch Tower Bible and Tract Society of Pennsylvania, N.Y. Awake! (ISSN 0005-237X). VOL. 104, No. 1 2023 ENGLISH. Pp. 2, 9 – 11.

FAO (2022). The State of the World's Forests 2022. Forest Pathways for Green Recovery and Building Inclusive, Resilient and Sustainable Economies. Rome, FAO. https://doi.org/10.4060/cb9360enUN. Country Profile, Nigeria: 1-82. Available Online at http://www.fao.org/3/a-az293e.

Frohn, R. C., Reif, M., Lane, C., & Autrey, B. (2009). Satellite Remote Sensing of Isolated Wetlands using Object-oriented Classification of Landsat-7 Data. Wetlands, 29(3), 931- 941. https://earthexplorer.usgs.gov/

Negassa, M. D., Mallie, D. T., & Gemeda, D. O. (2020). Forest Cover Change Detection using Geographic Information Systems and Remote Sensing Techniques: a Spatio-temporal Study on Komto Protected forest priority area, East Wollega Zone, Ethiopia. *Environmental Systems Research*, *9*, 1-14.

Ogunwale, A.O. (2015). Deforestation and Greening the Nigerian Environment. *International Conference on African Development Issues (CU-ICADI) 2015: Renewable Energy Track.* Nigeria Institute of Social and Economic Research (NISER) lbadan, Nigeria. Pp. 212.

Olorunfemi, I. E., Komolafe, A. A., Fasinmirin, J. T., & Olufayo, A. A. (2019). Biomass carbon stocks of different land use management in the forest vegetative zone of Nigeria. *Acta Oecologica*, *95*, 45-56.

Yusuf, A. A. and Razaq, A. O. (2024). The Challenges of Deforestation and Management in Nigeria: Suggestions for Improvement. *Ghana Journal of Geography* Vol. 16 (1), 2024 pages 193-220 Doi: https://dx.doi.org/10.4314/gjg.v16i1.7